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(54) **METHOD OF MANUFACTURING LIGHT EMITTING DEVICE HAVING LIGHT GUIDING MEMBER IN GROOVE**

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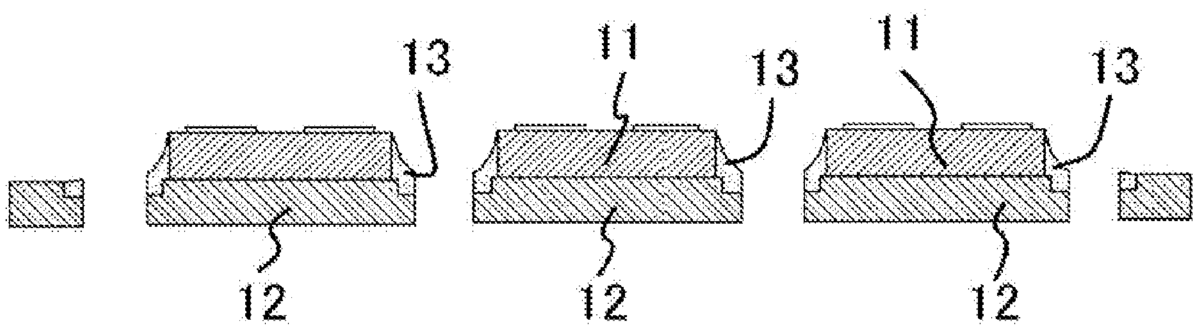
(57) **ABSTRACT**

A method of manufacturing a light emitting device includes: bonding a plurality of light emitting elements each having an outer peripheral lateral surface onto a light-transmissive substrate; forming at least one groove on the light-transmissive substrate to surround an outer periphery of each of the plurality of light emitting elements; disposing at least one light guiding member in the groove to continuously cover the groove and the outer peripheral lateral surfaces of adjacent ones of the plurality of light emitting elements; and singulating the light-transmissive substrate at a position between adjacent ones of the plurality of light emitting elements, to obtain a plurality of light emitting devices in each of which at least one of the light emitting elements is bonded to a single light-transmissive member.

14 Claims, 5 Drawing Sheets



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H01L 33/36	(2010.01)
H01L 33/56	(2010.01)
H01L 33/58	(2010.01)
H01L 51/56	(2006.01)
H01L 33/54	(2010.01)

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FIG. 1A

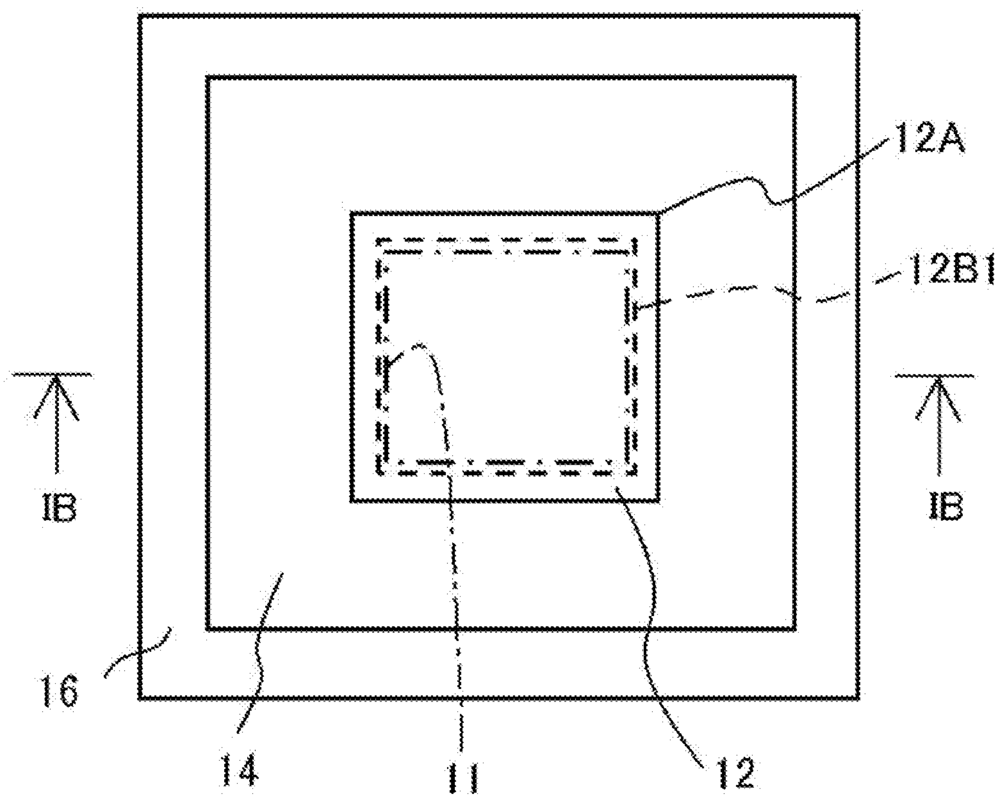


FIG. 1B

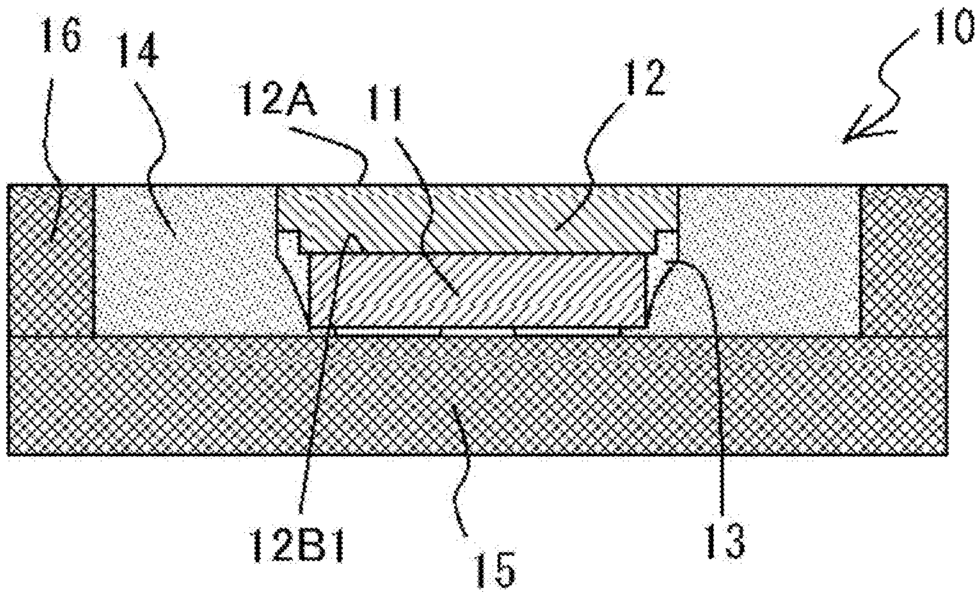


FIG. 1C

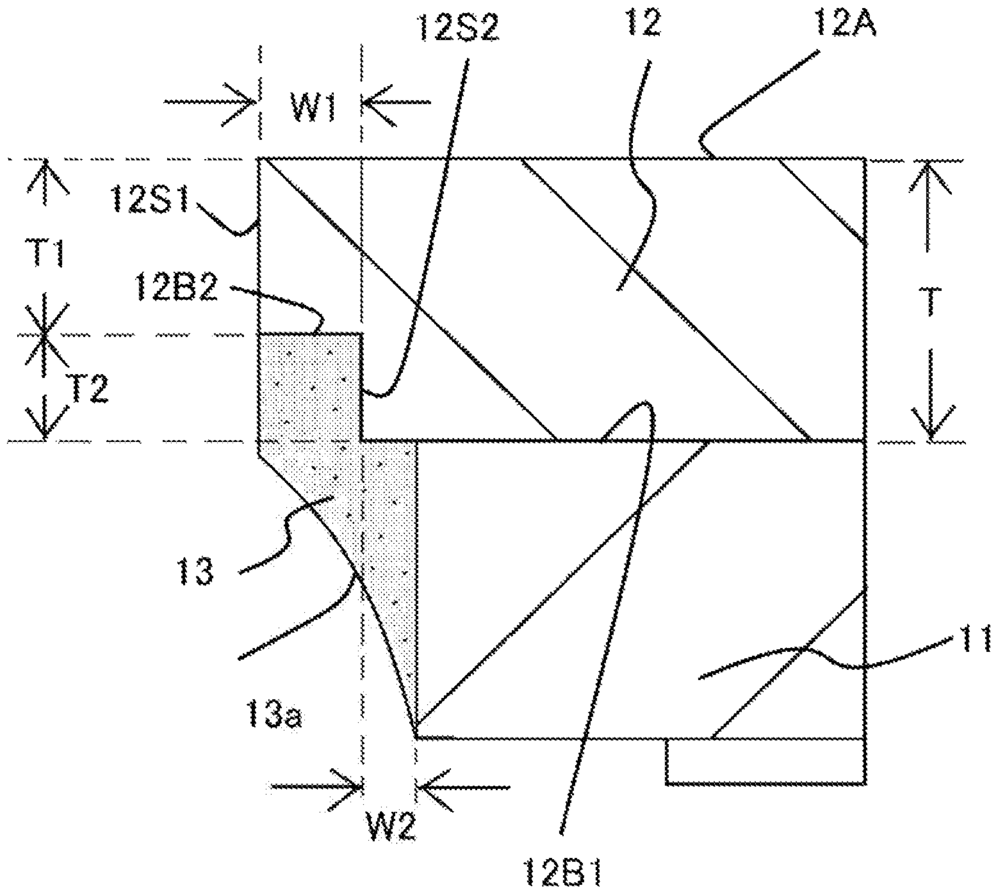

12S2
12
12A
W1
12S1
T1
12B2
T
T2
13
11
13a
W2
12B1

FIG. 1D

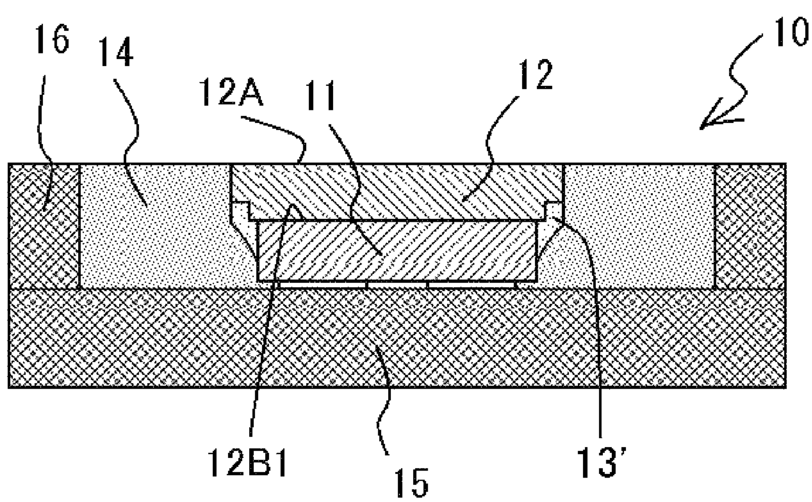

16
14
12A
11
12
10
12B1
15
13'

FIG. 2A

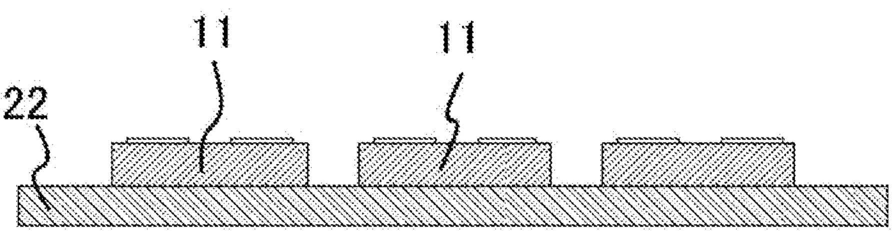


FIG 2B

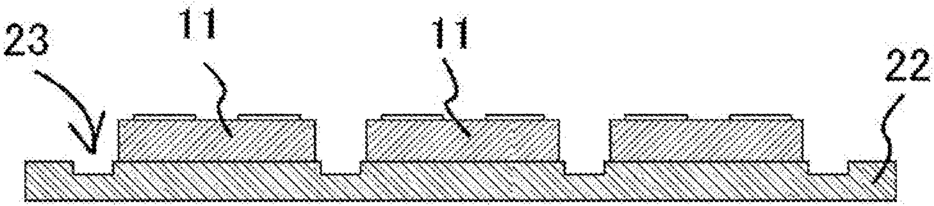


FIG. 2C

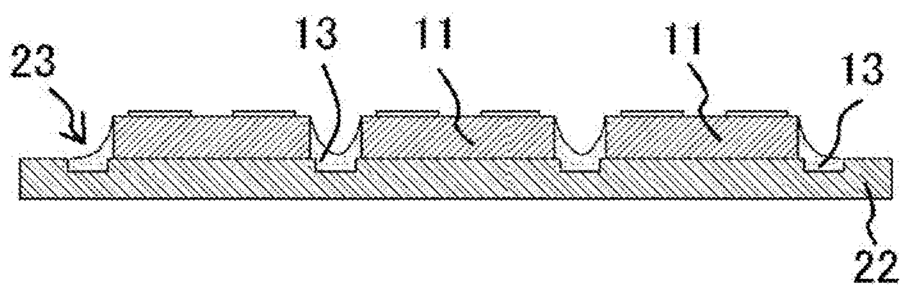


FIG. 2D

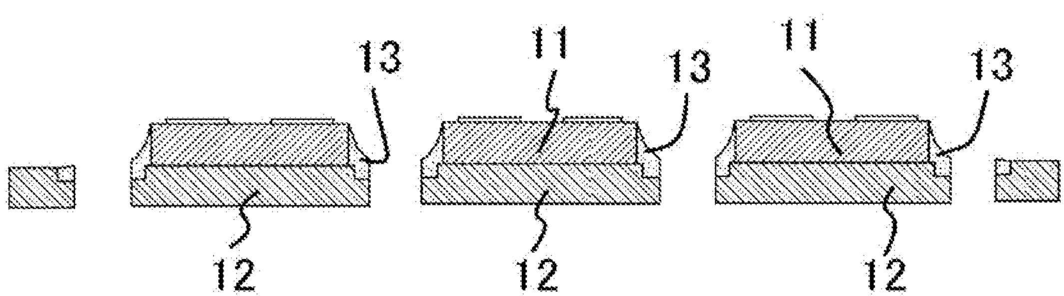
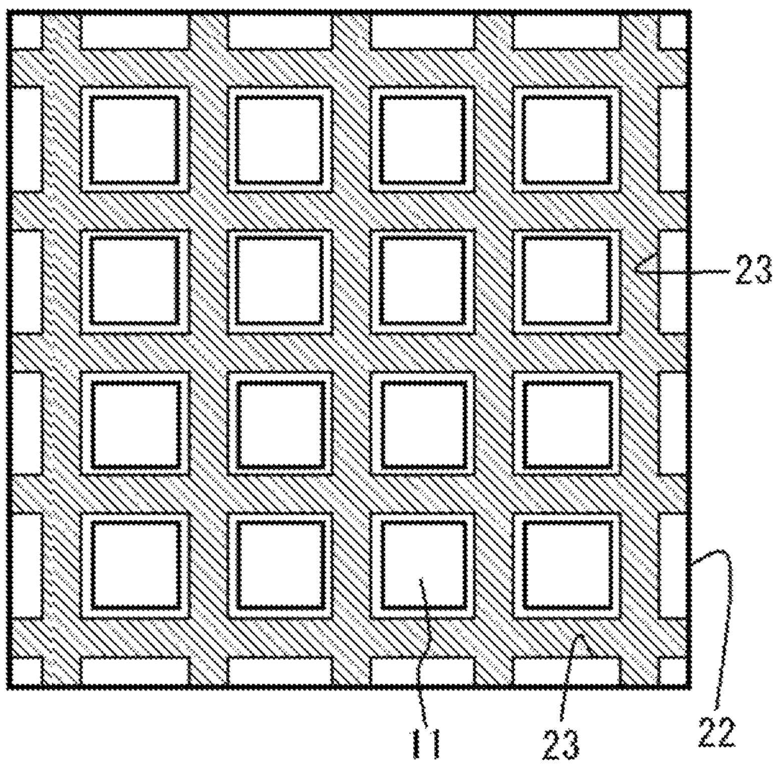


FIG. 3



METHOD OF MANUFACTURING LIGHT EMITTING DEVICE HAVING LIGHT GUIDING MEMBER IN GROOVE

CROSS-REFERENCE TO RELATED APPLICATION

This application is a divisional application of U.S. patent application Ser. No. 15/960,051 filed on Apr. 23, 2018. This application claims priority to Japanese Patent Application No. 2017-089785 filed on Apr. 28, 2017. The entire disclosures of U.S. patent application Ser. No. 15/960,051 and Japanese Patent Application No. 2017-089785 are hereby incorporated herein by reference.

BACKGROUND

1. Technical Field

The present disclosure relates to a light emitting device and a method of manufacturing the light emitting device.

2. Description of Related Art

There has been proposed a light emitting device including a light emitting element and a plate-like optical layer mounted on the upper surface of the light emitting element via a transparent material layer (for example, see JP 2012-4303 A).

In the light emitting device such as described in JP 2012-4303 A, light emitting area is reduced, and the light extraction efficiency is improved.

SUMMARY

With the plate-like optical layer having a lower surface greater than the upper surface of the light emitting element, light distribution is uneven between the light extraction surface of the light emitting element and the outer peripheral portion of the light emitting element. Thus, this structure tends to cause light emission unevenness.

An object of the present disclosure is to provide a light emitting device in which color unevenness at its light emitting surface can be reduced and a method of manufacturing the light emitting device.

A method of manufacturing a light emitting device according to one embodiment of the present disclosure includes: bonding a plurality of light emitting elements each having an outer peripheral lateral surface onto a light-transmissive substrate; forming at least one groove on the light-transmissive substrate to surround an outer periphery of each of the plurality of light emitting elements; disposing at least one light guiding member in the groove to continuously cover the groove and the outer peripheral lateral surfaces of adjacent ones of the plurality of light emitting elements; and singulating the light-transmissive substrate at a position between adjacent ones of the plurality of light emitting elements, to obtain a plurality of light emitting devices in each of which at least one of the light emitting elements is bonded to a single light-transmissive member.

Certain embodiments of the present disclosure provides a light emitting device in which color unevenness at its light emitting surface can be reduced, and a method of manufacturing the light emitting device.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is a schematic plan view schematically showing the structure of a light emitting device according to an embodiment of the present disclosure.

FIG. **1**B is a cross-sectional view taken along a line IB-IB in FIG. **1**A.

FIG. **1**C is an enlarged view of a part of FIG. **1**B.

FIG. **1**D is a cross-sectional view showing the structure of a light emitting device according to another embodiment of the present disclosure.

FIG. **2**A is a schematic cross-sectional view schematically showing a method of manufacturing the light emitting device shown in FIG. **1**A.

FIG. **2**B is a schematic cross-sectional view schematically showing the method of manufacturing the light emitting device shown in FIG. **1**A.

FIG. **2**C is a schematic cross-sectional view schematically showing the method of manufacturing the light emitting device shown in FIG. **1**A.

FIG. **2**D is a schematic cross-sectional view schematically showing the method of manufacturing the light emitting device shown in FIG. **1**A.

FIG. **3** is a schematic plan view corresponding to the schematic cross-sectional view in FIG. **2**B.

DETAILED DESCRIPTION OF EMBODIMENTS

With reference to the drawings, a description will be given below of a light emitting device according to an embodiment of the present disclosure and a method of manufacturing the light emitting device. The drawings referred to in the description below are intended to schematically show certain embodiments of the present invention, the scale, interval, positional relationship and the like of the members may be exaggerated, or the members may be partially omitted. Further, in the following description, basically the same or similar members are denoted by the same name or reference numeral, and a detailed description thereof may not be repeated as appropriate.

Light Emitting Device

As shown in FIGS. **1**A to **1**C, the light emitting device according to the present embodiment includes a light emitting element **11**, a light-transmissive member **12** disposed above the light emitting element **11**, a light guiding member **13** covering the lateral surfaces of the light emitting element **11** and a lower surface of the light-transmissive member **12**, and a covering member **14** covering the lateral surfaces of each of the light guiding member **13** and the light-transmissive member **12**. Such a light emitting device **10** can be used for, for example, a light source for general illumination, a light source for a vehicle, or the like.

In the light emitting device **10**, as will be described below, a lower surface of the light-transmissive member **12**, which is a surface of the light-transmissive member **12** at a light emitting element side, includes a projecting portion in contact with a light extraction surface of the light emitting element. In other words, the light-transmissive member **12** has two lower surfaces having heights from the upper surface different from each other. Thus, the light-transmissive member **12** in which a thickness thereof at the outer peripheral part of the light extraction surface of the light emitting element **11** (that is, a thickness thereof on an outer side of the light emitting element **11** in a plan view) is smaller than a thickness of the central part (that is, a region overlapping the light emitting element **11** in a plan view) can be disposed. With the light-transmissive member **12** having such a structure, unevenness in light emission can be effectively reduced at the light emitting surface of the light emitting device **10** in which the upper surface of the light-transmissive member **12** is the light emitting surface.

With the light-transmissive member **12** disposed so as to be in contact with the light emitting element **11**, light emitted from the light emitting element **11** is incident on the projecting portion of the light-transmissive member **12** (that is, a region overlaid on the light emitting element **11** in a plan view), without passing through another member (for example, an adhesive agent or the like) which is otherwise conventionally disposed between the light emitting element **11** and the light-transmissive member **12**. Thus, light absorption or light reflection due to another member disposed between the light emitting element **11** and the light-transmissive member **12** can be avoided, so that the light extraction efficiency can be improved. On the other hand, light emitted from the light emitting element **11** is incident on a region other than the projecting portion of the lower surface of the light-transmissive member **12** (that is, a region on an outer side of the light emitting element **11** in a plan view) mainly via the light guiding member **13**. Accordingly, reducing the thickness of the light-transmissive member **12** at this region allows for reducing the difference in luminance between the central part and the outer peripheral part of the upper surface of the light-transmissive member **12**. In particular, in the case where the light-transmissive member **12** contains a fluorescent material which will be described below, this structure effectively allows for reducing color unevenness at the outer peripheral part.

Light Emitting Element 11

The light emitting element **11** is preferably a light emitting diode including a semiconductor layer that includes an n-type semiconductor layer, a p-type semiconductor layer, and a light emitting layer. The wavelength of the light emitting element **11** may be appropriately selected according to the purpose and intended use thereof. In the light emitting element **11**, one surface side of the semiconductor layer is the main light extraction surface. Examples of the light emitting element **11** configured to emit blue light (i.e., light having a wavelength in a range of 430 nm to 490 nm) or green light (i.e., light having a wavelength in a range of 490 nm to 570 nm) include a light emitting element in which a semiconductor layer such as ZnSe, a nitride-based semiconductor ($In_XAl_YGa_{1-X-Y}N$, $0 \leq X$, $0 \leq Y$, $X+Y \leq 1$), or GaP is used. Further, examples of the light emitting element **11** configured to emit red light (i.e., light having a wavelength in a range of 620 nm to 750 nm) include a light emitting element in which semiconductor layer such as GaAlAs or AlInGaP is used. As will be described below, in the case where the light emitting device **10** contains a fluorescent material, the light emitting device **10** preferably includes a nitride semiconductor ($In_XAl_YGa_{1-X-Y}N$, $0 \leq X$, $0 \leq Y$, $X+Y \leq 1$) for emitting light of a short wavelength, which can efficiently excite the fluorescent material. The component composition, color of emitted light, size or the like of the light emitting element **11** may be selected as appropriate according to the purpose and intended use of the light emitting element **11**.

The light emitting element **11** includes a plurality of electrodes connected to the semiconductor layer. While the plurality of electrodes may be disposed respectively on different surfaces of the semiconductor layer, preferably they are disposed on the same surface of the semiconductor layer. This allows the light emitting element **11** to be flip-chip mounted on the substrate **15**. In the case where the light emitting element **11** is flip-chip mounted on the substrate **15** such that the surface where the plurality of electrodes is formed faces downward to be the lower surface, the upper surface opposite to the lower surface serves as the main light extraction surface of the light emitting element **11**.

Any of various shapes such as a circle, an oval, or a polygon such as a square or a hexagon may be employed as a planar shape of the light emitting element **11**. The planar shape of the light emitting element **11** is preferably a quadrangle such as a square, a rectangle or the like, or a regular hexagon. The size of the light emitting element **11** may be selected as appropriate in accordance with the intended use, the desired performance and the like.

As will be described below, at the light extraction surface of the light emitting element **11**, the light-transmissive member **12** is disposed so as to be in contact therewith. As will be described below, the light-transmissive member **12** is preferably directly bonded and fixed without using an adhesive agent or the like. Accordingly, the light extraction surface of the light emitting element **11** is preferably smooth. For example, the surface roughness Ra of the light extraction surface is preferably 1.0 nm or smaller, and further preferably 0.3 nm or smaller. The surface roughness Ra as used herein refers to the value represented as the "arithmetic average roughness Ra" in HS B0601:2013.

Light-Transmissive Member 12

The light-transmissive member **12** is disposed so as to be in contact with the light extraction surface of the light emitting element **11**.

The light-transmissive member **12** includes a projecting portion at its lower surface facing the light emitting element. In other words, the light-transmissive member **12** includes a first lower surface **12B1**, an upper surface **12A**, first lateral surfaces **12S1**, second lateral surfaces **12S2**, and a second lower surface **12B2**. More specifically, the light-transmissive member **12** includes the first lower surface **12B1** in contact with the light extraction surface of the light emitting element **11**, the upper surface **12A** opposite to the first lower surface **12B1**, the first lateral surfaces **12S1** connected to the upper surface **12A**, the second lateral surfaces **12S2** on an inner side of the first lateral surfaces, and the second lower surface **12B2** between the first lateral surfaces **12S1** and the second lateral surfaces **12S2**. The height from the first lower surface **12B1** to the upper surface **12A** of the light-transmissive member **12** is greater than the height from the second lower surface **12B2** to the upper surface **12A**.

The upper surface **12A** and the first lower surface **12B1** of the light-transmissive member **12** are surfaces opposite to each other, and are preferably opposite to each other so as to be in parallel.

The first lower surface **12B1** of the light-transmissive member **12** is in contact with the light extraction surface of the light emitting element **11** and preferably, as will be described below, is directly bonded and fixed to the light extraction surface of the light emitting element **11** without using an adhesive agent or the like. This structure allows for preventing light absorption or light reflection, which would otherwise occur, by an adhesive agent or the like that are conventionally used. Accordingly, light emitted from the light emitting element can be incident on the light-transmissive member **12** without being influenced by an adhesive agent or the like. This allows for improving the light extraction efficiency of the light emitting device **10** in which the upper surface of the light-transmissive member **12** is the light emitting surface.

The first lower surface **12**B**1** is directly bonded to the light extraction surface of the light emitting element **11** using various kinds of bonding methods, which will be described below. Accordingly, the first lower surface **12**B**1** is preferably smooth, for example, having an Ra of 1.0 nm or smaller, more preferably 0.3 nm or smaller.

The first lower surface **12**B**1** may have a size similar to a size of the light extraction surface of the light emitting element **11** (that is, the upper surface of the light emitting element **11**), but a size of the first lower surface **12**B**1** is preferably slightly greater than the light extraction surface of the light emitting element **11** so as to enclose the light extraction surface of the light emitting element **11**. For example, the first lower surface **12**B**1** preferably has an area 100% to 120% of an area of the light extraction surface of the light emitting element **11**. Preferably, a portion or an entirety of the outer edge of the first lower surface **12**B**1** is located on an outer side of the outer edge of the light extraction surface of the light emitting element **11**. More preferably, an entirety of the outer edge of the first lower surface **12**B**1** is disposed on an outer side of the outer edge of the light extraction surface of the light emitting element **11**. Further, the first lower surface **12**B**1** is preferably disposed so that its center substantially coincides with the center of the light extraction surface of the light emitting element **11**. Further, similarly to the light emitting element **11**, while the first lower surface **12**B**1** may have any of various planar shapes, the first lower surface **12**B**1** preferably has a shape of a quadrangle such as a square or a rectangle, or a regular hexagon. More preferably, the first lower surface **12**B**1** has the same or similar shape as a shape of the light extraction surface of the light emitting element **11**.

For example, a distance W**2** between the outer edge of the first lower surface **12**B**1** and the outer edge of the light extraction surface of the light emitting element **11** may be in a range of 10 μm to 50 μm, preferably 10 μm to 40 μm, more preferably 15 μm to 30 μm. In this manner, with the first lower surface **12**B**1** of the light-transmissive member **12** having a portion exposed from the light extraction surface of the light emitting element **11**, a path of light propagating obliquely from the light extraction surface of the light emitting element toward the outer edge of the upper surface **12**A of the light-transmissive member **12** can be obtained. That is, in a cross-sectional view, it is preferable that the distance W**2** allows for obtaining a path of a straight line connecting an end portion of the upper surface of the light-transmissive member **12** and an end portion of the light extraction surface of the light emitting element **11**.

The upper surface **12**A of the light-transmissive member is a surface that constitutes, as the light emitting surface of the light emitting device **10**, a portion of an outer surface (for example, the upper surface) of the light emitting device **10**. The upper surface **12**A is opposite from the first lower surface **12**B**1**, and has an area greater than that of the first lower surface **12**B**1**. For example, an area of the upper surface **12**A is greater than the area of the first lower surface **12**B**1**, and preferably has an area of up to about 150% of the area of the first lower surface **12**B**1**. The upper surface **12**A is preferably disposed such that its center coincides with the center of the first lower surface **12**B**1**. Further, the upper surface **12**A has a size greater than a size of the light extraction surface of the light emitting element **11**, and preferably has an area of up to about 170% of the area of the light extraction surface of the light emitting element **11**. The upper surface **12**A is preferably disposed such that its center substantially coincides with the center of the light extraction surface of the light emitting element **11**.

Similarly to the light emitting element **11**, the upper surface **12**A may have any of various planar shapes, but preferably the planar shape thereof is a quadrangle such as a square or a rectangle, or a regular hexagon. In view of light emission distribution, the planar shape of the upper surface **12**A is more preferably similar to the shape of the light extraction surface of the light emitting element **11**.

The upper surface **12**A may include small irregularities. Such irregularities allow for facilitating scattering of light emitted from the upper surface **12**A, so that the extraction efficiency of light from the upper surface **12**A can be improved.

The first lateral surfaces **12S1** of the light-transmissive member **12** are lateral surfaces of the light-transmissive member **12** connected to the upper surface **12**A. While the first lateral surfaces **12S1** are preferably substantially perpendicular to the upper surface **12**A, the first lateral surfaces **12S1** may be slightly narrowed, widened, or narrowed and widened toward the lower surface side. For example, the angle between the first lateral surface **12S1** and the upper surface **12**A may be in a range of approximately 90±10 degrees. Further, the connecting portions between the first lateral surfaces **12S1** and the upper surface **12**A may be rounded. Each of the first lateral surfaces **12S1** may be a curved surface or a surface including a curved surface.

Each of the first lateral surfaces **12S1** may be smooth or may have small irregularities.

The height of each of the first lateral surfaces **12S1**, in other words, a height T**1** from the upper surface **12**A to the second lower surface **12**B**2**, which will be described below, can be in a range of 2/10 to 8/10, preferably 3/10 to 7/10, more preferably 3/10 to 6/10, and further preferably 3/10 to 5/10 of the overall height T of the light-transmissive member **12**. More specifically, the height of the first lateral surface **12S1** may be in a range of 30 μm to 200 μm, preferably 40 μm to 180 μm, and more preferably 50 μm to 165 μm. Such a height allows for obtaining the mechanical strength of the light-transmissive member **12** during manufacturing. Further, in the light emitting device **10** having first lateral surfaces **12S1** that are covered with the covering member **14** which will be described below, the difference in luminance between the light emitting portion and the non-light emitting portion can be more conspicuous.

The second lateral surfaces **12S2** are lateral surfaces of the light-transmissive member **12** positioned on an inner side of the first lateral surfaces **12S1** of the light-transmissive member **12** and connected to the first lower surface **12**B**1**.

The second lateral surfaces **12S2** are preferably substantially perpendicular to the first lower surface **12**B**1**, but the second lateral surfaces **12S2** may be slightly narrowed or widened toward the upper surface side. For example, the allowable degree thereof may be about 90±10. Further, the coupling portion between them may be rounded. The second lateral surface **12S2** may be a curved surface or a surface including a curved surface.

A height of each of the second lateral surfaces **12S2**, in other words, a height T**2** from the first lower surface **12**B**1** to the second lower surface **12**B**2**, which will be described below, can be in a range of 2/10 to 8/10, preferably 3/10 to 7/10, more preferably 3/10 to 6/10, and further preferably 3/10 to 5/10 of the total height T of the light-transmissive member **12**. More specifically, the height can be in a range of 30 μm to 200 μm, preferably 40 μm to 180 μm, and more preferably

50 μm to 165 μm. Such a height reliably allows for obtaining mechanical strength of the light-transmissive member **12** during manufacturing.

Each of the second lateral surfaces **12S2** may be smooth or may have small irregularities.

Depending on the manner of processing the second lateral surfaces **12S2**, the boundary between the second lateral surface **12S2** and the second lower surface **12B2**, which will be described below, may not clearly exist, and the second lateral surface **12S2** and the second lower surface **12B2** may be continuous with each other. For example, the second lateral surface **12S2** and the second lower surface **12B2** may be continuous to each other to be a curved surface. The curved surface in this case can be inwardly depressed and outwardly projected. Such a curved surface is regarded as the second lateral surface **12S2** so long as the light-transmissive member **12** includes an outer peripheral portion having a thickness smaller than a thickness of the central portion of the light-transmissive member **12**.

The second lower surface **12B2** is connected to both the first lateral surfaces **12S1** and the second lateral surfaces **12S2**, and disposed at a part of or the entirety of the outer periphery of the first lower surface **12B1**.

A width **W1** of the second lower surface **12B2** is, for example, about 2.5% to 7.5% of a length of one side of the light emitting element **11**. In view of another aspect, for example, the width **W1** may be in a range of 10 μm to 200 μm, preferably 20 μm to 100 μm, and more preferably 50 μm to 75 μm. Thus, in combination with the shape of the light guiding member **13** which will be described below, unevenness in light emission at the outer periphery of the light-transmissive member **12** can be reduced. The "width **W1**" refers to the distance between each of the first lateral surfaces **12S1** and a respective one of the second lateral surfaces **12S2**, more specifically, the distance between the outermost portion of each of the first lateral surfaces **12S1** to the outermost portion of a respective one of the second lateral surface **12S2**. Note that, the width W1 of the second lower surface **12B2** is preferably constant along the outer periphery of the first lower surface **12B1**, but the width W1 may be partially increased or reduced.

For the light-transmissive member **12**, for example, an inorganic material such as a resin molded body, ceramic, glass, or the like can be used. As used herein, the term "light transmissive" refers to that a base material of the light-transmissive member **12** transmits 60% or more, preferably 70% or more, and more preferably 80% or more of light emitted from the light emitting element.

The light-transmissive member **12** preferably contains a fluorescent material. Examples of the light-transmissive member **12** containing a fluorescent material includes a sintered body of a fluorescent material, resin, glass, ceramic, or other inorganic material containing a fluorescent material. For the fluorescent material, fluorescent materials known in the art, such as a yttrium-aluminum-garnet-based fluorescent material (a YAG-based fluorescent material), a nitride-based fluorescent material, an oxynitride fluorescent material, a K_2SiF_6:Mn-based fluorescent material (a KSF fluorescent material), and a sulfide-based fluorescent material can be appropriately used. These fluorescent materials are used in desired combination and/or with a desired blending ratio suitable for a desired color to adjust color rendering and color reproductivity. With the light-transmissive member **12** containing a fluorescent material, light emitted toward outside from the upper surface of the light-transmissive member **12** is a mixed-color light which is the mixture of light emitted from the light emitting element **11** and light having a wavelength converted by the fluorescent material. Accordingly, for example, allowing blue emitted from the light emitting element **11** and yellow-color light obtained by converting a wavelength of a portion of the blue light by a fluorescent material to mix with each other allows for obtaining the light emitting device **10** configured to emit white light.

A YAG-based fluorescent material is a representative fluorescent material with which emission of white mixed-color light can be obtained in a suitable combination with a blue-color light emitting element. Examples of the YAG-based fluorescent material include, for example, $(Re_{1-x}Smx)_3(Al_{1-y}Gay)_5O_{12}$:Ce ($0 \le x < 1$, $0 \le y \le 1$, where Re is at least one element selected from the group consisting of Y, Gd, and La) or the like.

In the case where the light emitting device configured to emit white light using a YAG-based fluorescent material is to be obtained, the concentration of the fluorescent material contained in the light-transmissive member **12** can be selected as appropriate so as to realize emission of white light. For example, the concentration of the fluorescent material contained in the light-transmissive member **12** may be in a range of 5 wt % to 50 wt %.

Further, using a blue light emitting element for the light emitting element **11** and using a YAG-based fluorescent material and a nitride-based fluorescent material containing a greater amount of a red-color component for a fluorescent material allows emission of light of amber color. The expression "amber color" refers to, in JIS standard Z8110, the region consisting of a long wavelength region in yellow color and a short wavelength region in yellow-red color, and the chromaticity range between the yellow region and the yellow-red short wavelength region in JIS standard Z9101, which is related to safety colors. For example, the "amber color" refers to the region of the dominant wavelength in a range of 580 nm to 600 nm as. Many of fluorescent materials adapted to emit amber color has low light conversion efficiency, so that a concentration of fluorescent material is preferably increased in order to obtain a desired color. Further, while heat generation of the fluorescent material adapted to emit amber-color light is greater than heat generation of other fluorescent materials, reducing the thickness of the light-transmissive member **12** and increasing the fluorescent material concentration allows the fluorescent material adapted to emit amber-color light to be suitably used.

The nitride-based fluorescent material is expressed as, for example, $CaAlSiN_3$:Eu, $(Sr,Ca)AlSiN_3$:Eu, $(Sr,Ca)_2Si_5N_8$:Eu, $(Sr,Ca)Si_7N_{10}$:Eu or the like.

For the light-transmissive member **12**, a light emitting substance such as a so-called nanocrystal, quantum dots or the like may be used. Examples of such a material may be a semiconductor material include a Group II-VI, Group III-V, or Group IV-VI semiconductor, specifically, nano-sized highly dispersed particles of CdSe, core-shell type CdS_XSe_{1-X}/ZnS, GaP, InAs or the like. Such a fluorescent material may have a particle size in a range of, for example, about 1 nm to 100 nm, preferably about 1 nm to 20 nm. Using such a light-transmissive member **12** allows for reducing the internal scattering and scattering of color-converted light, allows for further improving transmittance of light.

The light-transmissive member **12** may be formed as a single layer made of one type of a material or as a single layer made of two or more types of materials being mixed with each other. Alternatively, in the light-transmissive member **12**, two or more single layers may be layered.

Further, as necessary, the light-transmissive member **12** may contain a light diffusing material. Increase in concentration of fluorescent material in the light-transmissive member **12** tends to cause unevenness in emission color. However, with the light-transmissive member **12** containing a light diffusing material, unevenness in emission color and in luminance can be reduced. Examples of the light diffusing material include titanium oxide, barium titanate, aluminum oxide, silicon oxide and the like.

The light-transmissive member **12** has a thickness T that allows for preventing a reduction in mechanical strength during manufacturing and providing sufficient mechanical strength to the light-transmissive member **12**. For example, the thickness T may be 50 μm or more. Further, in view of ease of processing, the thickness T may be, for example, 300 μm or smaller. In view of these, the thickness T of the light-transmissive member **12** may be in a range of, for example, 50 μm to 300 μm, preferably 70 μm to 300 μm, and more preferably 100 μm to 200 μm.

Light Guiding Member **13**

The light guiding member **13** covers at least a portion of each of the lateral surfaces of the light emitting element **11**. Further, the light guiding member **13** covers at least a portion of each of the second lateral surfaces and the second lower surface of the light-transmissive member **12**. In other words, the light guiding member **13** covers the lateral surfaces of the light emitting element **11** and the lateral surfaces of the projecting portion of the light-transmissive member **12**. In the case where the first lower surface **12**B**1** of the light-transmissive member **12** is larger than the light extraction surface of the light emitting element **11**, the first lower surface **12**B**1** not in contact with the light extraction surface of the light emitting element **11** is also covered with the light guiding member **13**. It is preferable that the first lateral surfaces **12**S**1** of the light-transmissive member **12** are not covered with the light guiding member **13**. With the light guiding member **13** not covering the first lateral surfaces **12**S**1** of the light-transmissive member **12**, that is, with the light guiding member **13** spaced apart from the light emitting surface of the light emitting device **10**, leakage of light from the light guiding member **13** to the outside can be reduced. Thus, the light emitting surface of the light emitting device **10** can be limited to be the upper surface **12**A of the light-transmissive member **12**.

As shown in FIG. **1**C, the light guiding member **13** is disposed so as to extend from a lateral surface of the light emitting element **11** to the second lower surface **12**B**2** of the light-transmissive member **12**. A thickness of the light guiding member **13** covering a lateral surface of the light emitting element **11** (that is, a width of the light guiding member **13** in a planar direction as measured between the lateral surface of the light emitting element **11** and the lateral surface of the light guiding member **13**) increases toward the light-transmissive member **12** (that is, toward the upper surface of the light emitting device **10**). Further, it is preferable that the thickness of the light guiding member **13** reduces toward the lower surface of the light emitting element **11** so that light guiding member **13** has a substantially triangular shape in a cross-sectional view. The lateral surfaces **13***a* of the light guiding member **13** opposite to the surfaces of the light guiding member **13** facing the lateral surfaces of the light emitting element **11** may be a flat surface surrounding the outer periphery of the light emitting element **11**, or may be curved surfaces each of which is inwardly recessed and outwardly projected. Further, it is preferable that a portion of the light guiding member **13** covering the second lateral surfaces **12**S**2** of the light-transmissive member **12** has substantially the same thickness entirely along the height direction of the second lateral surface **12**S**2**.

With the light guiding member **13** having lateral surfaces each having such a shape, light emitted from the light emitting element **11** spreads over the planar area similar to the area of the upper surface **12**A of the light-transmissive member **12**, and thereafter is incident on the second lower surface **12**B**2** of the light-transmissive member **12**. Thus, light emitted from the light emitting element **11** easily reaches an end portion of the second lower surface **12**B**2** of the light-transmissive member **12** and, consequently, light emission unevenness at the upper surface **12**A of the light-transmissive member **12** can be reduced.

As to the light guiding member **13**, the maximum thickness of the light guiding member **13** at a portion covering the lateral surfaces of the light emitting element **11** is preferably equal to or smaller than the total length of the width W**1** of the second lower surface **12**B**2** and the distance W**2** between the outer edge of the first lower surface **12**B**1** and the outer edge of the light extraction surface of the light emitting element **11** (that is, the distance between each of the lateral surfaces of the light emitting element **11** and a respective one of the first lateral surfaces **12**S**1** of the light-transmissive member **12**), and equal to or greater than the width W**1** of the second lower surface **12**B**2** of the light-transmissive member **12**.

The outer peripheral portion of the light guiding member **13** in contact with the second lower surface **12**B**2** may be located on an inner side of the outer edge of the second lower surface **12**B**2**, but it is preferable that the outer peripheral portion of the light guiding member **13** substantially coincides with the outer edge of the second lower surface **12**B**2**.

The lower end portion of the light guiding member **13** in contact with the lateral surfaces of the light emitting element **11** is preferably located at a position higher than a position of the lower end portion of the light emitting element **11**, or coincides with the lower end portion of the light emitting element **11**.

The light guiding member **13** preferably covers, for example, an entirety of the lateral surfaces of the light emitting element **11**, an entirety of each of the second lateral surfaces and second lower surface of the light-transmissive member **12**, and an entirety of a portion of first lower surface **12**B**1** not in contact with the light extraction surface of the light emitting element **11**. With this arrangement, light emitted from a lateral surface of the light emitting element **11** is reflected at the interface between the light guiding member **13** and the covering member **14**, which will be described below, and the light is incident on the light-transmissive member **12**. Further, light emitted from the second lateral surface **12**S**2** of the light-transmissive member **12** is reflected at the interface between the light guiding member **13** and the covering member **14**, which will be described below, and the light is incident on the light-transmissive member **12**. This allows for improving light extraction efficiency of light from the upper surface of the light-transmissive member **12**.

The light guiding member **13** is preferably made of a light-transmissive material that can guide light emitted from the light emitting element **11** to the light-transmissive member **12**. Examples of such a material include an organic resin such as epoxy resin, silicone resin, phenolic resin, and polyimide resin. Among these, silicone resin is preferable.

The material of light guiding member **13** may contain the above-described light diffusing member.

As described above, with the light guiding member **13** continuously covering the lateral surfaces of the light emitting element **11** and the lower surface of the light-transmissive member **12**, connection between the light emitting element **11** and the light-transmissive member **12** can be reinforced.

Covering Member 14

The covering member **14** covers the first lateral surfaces **12S1** of the light-transmissive member **12** and the lateral surfaces **13***a* of the light guiding member **13**. In the light emitting element **11**, in the case where a portion of each of the lateral surfaces of the light emitting element **11** is exposed from the light guiding member **13**, the covering member **14** covers the portion of the lateral surfaces of the light emitting element **11** exposed from the light guiding member **13'** as shown in FIG. **1**D. This allows substantially all the light emitted from the light emitting element **11** to be incident on the light-transmissive member **12**.

As will be described below, in the case where the light emitting element **11** and the like are mounted on the substrate **15**, the covering member **14** is preferably disposed also between the lower surface of the light emitting element **11** and the substrate **15**, and on the substrate **15**, in addition to at the lateral surfaces of each of the light-transmissive member **12**, the light guiding member **13**, and the light emitting element **11**.

For the covering member **14**, an insulating material is preferably used, and for example, a resin material is used. Examples of the resin materials include a resin containing at least one type of silicone resin, modified silicone resin, epoxy resin, modified epoxy resin, acrylic resin, phenolic resin, BT resin, and PPA, or hybrid resin. Among these, silicone resin, which has good heat resistance, electrical insulating property, and flexibility, is preferable. Further, the covering member **14** is preferably light reflective. The covering member **14** being light reflective can be obtained by causing the base material made of the above-described insulating material to contain a light reflecting substance. Examples of the light reflecting substance include titanium oxide, silicon oxide, zirconium oxide, magnesium oxide, calcium carbonate, calcium hydroxide, calcium silicate, zinc oxide, barium titanate, potassium titanate, alumina, aluminum nitride, boron nitride, mullite and the like. Among these, titanium oxide is relatively stable to moisture or the like and has a high refractive index, and thus is preferable. Further, for the covering member **14**, a ceramic may be used as an insulating material exhibiting good light reflectivity and heat dissipation property. Examples of such a ceramic include aluminum oxide, aluminum nitride, and boron nitride.

Substrate 15

The light emitting element **11** may be optionally mounted on the substrate **15**. The substrate **15** can collectively support the light emitting element **11**, the covering member **14**, and the like. Further, the substrate **15** electrically connects the light emitting device **10** to an external component. Accordingly, on a surface of the substrate **15**, a wiring pattern is formed for establishing electrical connection between an external power source and the light emitting element. The light emitting element and the like are preferably mounted on the wiring pattern.

In the case where a bonding member is used for mounting of the light emitting element **11** on the substrate **15**, a bump made of Au or alloy thereof, eutectic solder (Au—Sn), Pb—Sn, lead-free solder, or the like may be used for the bonding member.

For the substrate **15**, an insulating material that does not easily transmit light from the light emitting element **11** and external light is preferably used. Examples of a material of the substrate **15** include a ceramic such as alumina, aluminum nitride, mullite or the like, or a resin material such as phenolic resin, epoxy resin, polyimide resin, BT resin, polyphthalamide or the like. Alternatively, a composite material of an insulating material and a metal member may be employed. In the case of employing a resin as a material of the substrate **15**, as necessary, an inorganic filler such as glass fibers, silicon oxide, titanium oxide, alumina or the like may be mixed with the resin. This allows improvement in the mechanical strength, reduction in the thermal expansion coefficient, and improvement in the light reflectivity. The substrate **15** may have any appropriate thickness according to its purpose and intended use.

On the substrate **15**, in addition to the light emitting element **11** and the like, a frame body **16** for holding the covering member **14** may be disposed.

Electronic Component

The light emitting device **10** according to the present embodiment may include, as well as the light emitting element **11**, another electronic component adjacent to the light emitting element **11**. For the electronic component, a component not intended to serve to emit light from the light emitting device **10** may be used, such as a transistor for controlling the light emitting element, or a protective element such as a Zener diode to which electricity is supplied when a voltage of a predetermined voltage or more is applied. The protective element is electrically connected to be anti-parallel to the p-electrode and the n-electrode of the light emitting element **11**. With this structure, the voltage between the p-electrode and the n-electrode of the light emitting element **11** can be prevented from being equal to or greater than the Zener voltage, which allows for properly preventing element breakdown or decrease in performance of the light emitting element **11** due to application of an excessively great voltage.

These electronic components are preferably embedded in the covering member **14**.

In the light emitting device **10** having such a structure, the light-transmissive member **12** disposed on the light extraction surface of the light emitting element **11** and the light guiding member **13** efficiently allow substantially all the light emitted from the light emitting element **11** to be incident on the light-transmissive member **12**.

In particular, in the case where the light-transmissive member **12** contains a fluorescent material, reducing the thickness of the outer peripheral portion of the light-transmissive member **12** that does not overlap the light emitting element **11** allows for reducing the amount of the component of a specific color of light emitted from an end portion of the light emitting surface (that is, the upper surface of the light-transmissive member **12**), for example, the yellow-color component when YAG is employed. This structure allows for improving the front luminance, and effectively reducing occurrence of ring-like unevenness in emission color at the outer peripheral part of the light emitting surface.

Method of Manufacturing Light Emitting Device

A method of manufacturing a light emitting device according to the present embodiment includes:

bonding a plurality of light emitting elements **11** onto a light-transmissive substrate **22** (FIG. **2**A);

forming one or more grooves **23** on the light-transmissive substrate **22** so as to surround an outer periphery of each of the plurality of light emitting elements **11** (FIG. **2**B);

disposing at least one light guiding member **13** continuously covering inner side of the one or more grooves **23** and an outer peripheral lateral surface of each of the plurality of light emitting elements **11** (FIG. **2**C); and

dividing the light-transmissive substrate **22** at a position between the plurality of light emitting elements **11**, to obtain a light emitting device in which at least one of the light emitting elements **11** is bonded to a single light-transmissive member **12** (FIG. **2**D).

A: Bonding Light Emitting Element **11**

As shown in FIG. **2**A, a plurality of light emitting elements **11** are bonded onto the light-transmissive substrate **22**.

The plurality of light emitting elements **11** may be bonded onto the light-transmissive substrate **22** by using a method known in the art. Among these, a room-temperature bonding is preferably used. The room-temperature bonding is a bonding technique in which the light-transmissive substrate **22** and the light emitting elements **11** are bonded to each other, for example, under the temperature condition of a room temperature of 10° C. to 40° C., preferably 15° C. to 25° C. Examples of the room-temperature bonding include a surface activated bonding, in which the bonding surfaces are subjected to surface treatment in a vacuum to be activated, and the two bonding surfaces are bonded to each other without application of an adhesive agent, heat, pressure or the like. Examples of the room-temperature bonding further include an atomic diffusion bonding, in which a micro crystal film is formed at each of the bonding surfaces in an ultra-high vacuum, and the thin films are overlaid on each other in a vacuum so that the bonding surfaces are bonded to each other. Alternatively, a hydroxyl group bonding may be employed, in which a hydroxyl group containing film is formed at each of the bonding surfaces by the atomic layer deposition, and the bonding surfaces are bonded to each other. As examples of these methods, methods described in WO 2011/126000, JP 2015-29079 A, JP 2014-232866 A or the like may be used.

In the room-temperature bonding, each bonding surface is subjected to surface treatment in the air or in a vacuum. For example, in a vacuum, any oxide film, dirt or the like attached to the bonding surface is removed by irradiation of ions or plasma of argon or the like. The energy, time and the like in this case can be adjusted as appropriate. Such a treatment allows atoms having bonds to be exposed at the bonding surface, and exhibiting a very active state where high bonding property with other atoms is exhibited. Thus, by bringing the bonding surfaces into contact with each other, the bonding force instantaneously acts, so that the bonding surfaces are firmly bonded to each other. Further, because the bonding is carried out at the atomic level, the bonding exhibits higher strength and durability as compared with bonding through an adhesive agent or the like. Because such bonding does not cause thermal distortion or thermal stress attributed to heating, stable bonding can be realized.

In order to effectively carry out the room-temperature bonding, respective bonding surfaces between the light-transmissive substrate **22** and the light emitting element **11** to be bonded to each other are preferably highly smooth. More specifically, the arithmetic average roughness Ra of the bonding surfaces is preferably 1.0 nm or smaller, more preferably 0.3 nm or smaller. For a method of obtaining such a surface roughness of the bonding surfaces, any of known methods including the mechanical polishing, the chemical polishing, the chemical mechanical polishing or the like may be employed.

As shown in FIG. **3**, the plurality of light emitting elements **11** are preferably disposed on the light-transmissive substrate **22** in a regular manner (for example, in a matrix). More preferably, the light emitting elements **11** are arranged at regular intervals. The distance between adjacent ones of the light emitting elements **11** is selected in view of the dimension of each part of the light-transmissive member **12** to be obtained, and may be in a range of, for example, 100 μm to 500 μm.

The light-transmissive substrate **22** is a flat plate-shaped substrate made of the above-described material of the light-transmissive member **12**. While the bonding surfaces are very smooth as described above, surfaces other than the bonding surfaces may not be smooth and may have irregularities.

B: Forming Groove **23**

As shown in FIGS. **2**B and **3**, in the light-transmissive substrate **22**, the groove **23** surrounding the outer periphery of each of the plurality of light emitting elements **11** is formed.

The groove **23** is for demarcating the light-transmissive member **12** corresponding to the light emitting elements **11**. In the case where the plurality of light emitting elements **11** are arranged in a matrix on the light-transmissive substrate **22**, for example, the groove **23** may be formed to be a lattice shape as seen in a plan view. The groove **23** is formed with a blade having a predetermined width. The blade can have an appropriate width in view of a shape of the groove **23** to be obtained or the like. For example, the width of the groove **23** may be in a range of 20 μm to 200 μm, preferably 50 μm to 180 μm, and more preferably 100 μm to 150 μm. The groove **23** is preferably formed over a region between adjacent ones of the light emitting elements **11**. In particular, it is preferable to form the groove along the outer peripheries of the light emitting elements **11** to have a width that allows the groove to reach a position near a corresponding one of the lateral surfaces of the light emitting elements **11**. At this time, as shown in FIG. **3**, by forming the groove **23** so as to be spaced apart from the light emitting elements **11**, the blade for forming the groove and the light emitting elements are not brought into contact with each other even if, for example, accuracy in positions are varied during the plurality of light emitting elements on the light-transmissive substrate **22** are arranged in a matrix. Accordingly, occurrence of a damage to the light emitting elements can be reduced. Further, with the groove **23** and each light emitting element **11** to be spaced apart from each other, the light-transmissive member **12** can have the first lower surface having the dimension that allows the upper surface of the light emitting element to be located on an inner side of the periphery of the first lower surface of the light-transmissive member **12**.

The depth of the groove corresponds to the height T**2** (see FIG. **1**C) of the second lateral surface **12S2**, and is preferably approximately 3⁄10 to 7⁄10 of the total thickness T of the light-transmissive member **12**.

Instead of using a blade, the groove may be formed at the surface of the light-transmissive substrate using laser light, or using photolithography and etching technique.

C: Disposing Light Guiding Member **13**

As shown in FIG. **2**C, the light guiding member **13** is disposed in the groove **23** to continuously cover the groove **23** and the outer peripheral lateral surfaces of the plurality of light emitting elements **11**.

The light guiding member **13** can be made of the above-described material and formed by, for example, using a potting technique or printing. The light guiding member **13** is preferably formed such that a surface of the light guiding member **13** is recessed between the light emitting elements **11**. When the light guiding member **13** is formed by using a potting technique, such a surface shape can be controlled as appropriate by adjusting the amount and/or viscosity of the material. For example, by dropping a resin material being the material of the light guiding member **13** into the groove **23**, the resin material creeps up the lateral surfaces of each light emitting element **11** due to surface tension, so that a portion or an entirety of the lateral surfaces of each of the light emitting elements can be covered with the light guiding member **13**.

D: Singlating Light-Transmissive Substrate **22**

As shown in FIG. **2**D, the light-transmissive substrate **22** is singulated at positions between the plurality of light emitting elements **11**. Thus, the light emitting device in which one light emitting element **11** is bonded to one light-transmissive member **12** can be obtained.

The singulating of the light-transmissive substrate **22** can be performed by dividing the light-transmissive substrate **22** and the light guiding member **13** at positions between the light emitting elements **11**. The dividing can be carried out by, for example, cleaving the light-transmissive substrate **22** along the center of the groove **23** using a blade having a predetermined width. The blade used for the dividing has a width smaller than a width of the blade used in the forming of the groove **23**. The width of the blade used for the dividing may be in a range of, for example, 30 μm to 100 μm. With such a width, as shown in FIGS. **1**A to **1**C, the first lower surface **12**B**1** of the light-transmissive member **12** can be formed to be smaller than the upper surface **12**A by 50 μm to 75 μm.

The dividing may be carried out through use of laser light instead of the blade.

Thereafter, the obtained light emitting device (that is, the light emitting element **11** including the light-transmissive member **12** and the light guiding member **13**) may be mounted on the wiring pattern on the substrate **15** as shown in FIGS. **1**A and **1**B. The mounting of the light emitting element **11** is preferably carried out in a flip-chip manner.

Further, the obtained light emitting device (that is, the light emitting element **11** including the light-transmissive member **12** and the light guiding member **13**) may be optionally mounted on the substrate **15**, and thereafter the covering member **14** is disposed to surround the light-transmissive member **12** and the light guiding member **13**, and optionally on the substrate **15**.

The covering member **14** may be formed by, for example, using a resin discharging device or the like that can shift in the top-bottom direction or the horizontal direction with respect to the substrate **15**.

According to the method of manufacturing the light emitting device, in particular, forming the groove after mounting the light emitting element on the light-transmissive substrate allows for controlling the thickness of the light-transmissive member. That is, the light-transmissive member having the projecting portion, i.e., the first lower surface, the upper surface, the first lateral surfaces, the second lateral surfaces, and the second lower surface, can be manufactured highly precisely while reducing unevenness among a plurality of light emitting devices. Further, by adjusting the amount of the material of the light guiding member, the shape of the light guiding member is surely controlled, and the light guiding member having a proper shape can be disposed at proper position. Thus, a plurality of light emitting devices having good light extraction efficiency can be easily, precisely, and efficiently manufactured.

What is claimed is:

1. A method of manufacturing a light emitting device comprising:

bonding a plurality of light emitting elements each having an outer peripheral lateral surface onto a light-transmissive substrate;

forming at least one groove on the light-transmissive substrate to surround an outer periphery of each of the plurality of light emitting elements, a width of the groove along a horizontal width direction being constant along a depth direction of the groove;

disposing at least one light guiding member in the groove to continuously cover the groove and the outer peripheral lateral surfaces of adjacent ones of the plurality of light emitting elements; and

singulating the light-transmissive substrate at a position between adjacent ones of the plurality of light emitting elements, to obtain a plurality of light emitting devices in each of which at least one of the light emitting elements is bonded to a single light-transmissive member, a thickness of a portion of the at least one light guiding member covering the outer peripheral lateral surface of the at least one of the light emitting elements increases toward the light-transmissive member in a cross-sectional view, and a thickness of a portion of the at least one light guiding member covering a portion of a lateral surface of the light-transmissive member has a constant thickness in the cross-sectional view, the thickness being measured along the horizontal width direction.

2. The method of manufacturing a light emitting device according to claim **1**, further comprising

arranging the plurality of light emitting elements in a matrix on the light-transmissive substrate.

3. The method of manufacturing a light emitting device according to claim **1**, wherein

the forming of the at least one groove includes forming the at least one groove in a lattice shape in a plan view.

4. The method of manufacturing a light emitting device according to claim **1**, wherein

the forming of the at least one groove includes forming the at least one groove to have a depth of 3⁄10 to 7⁄10 of a thickness of the light-transmissive substrate.

5. The method of manufacturing a light emitting device according to claim **1**, further comprising

providing the light-transmissive substrate and the light emitting elements so that a surface roughness of a bonding surface of the light-transmissive substrate and a surface roughness of a bonding surface of each of the light emitting elements are each 1.0 nm or smaller.

6. The method of manufacturing a light emitting device according to claim 1, wherein
the disposing of the at least one light guiding member includes disposing the at least one light guiding member so that a surface of the at least one light guiding member is recessed between adjacent ones of the light emitting elements.

7. The method of manufacturing a light emitting device according to claim 1, wherein
the singulating of the light-transmissive substrate is carried out by dividing the light-transmissive substrate and the at least one light guiding member at a position at which the at least one groove is disposed.

8. The method of manufacturing a light emitting device according to claim 1, wherein
the light-transmissive member contains a fluorescent material.

9. The method of manufacturing a light emitting device according to claim 1, wherein
the disposing of the at least one light guiding member includes disposing the at least one light guiding member so that a lateral surface of the at least one light guiding member opposite to a surface facing the outer peripheral lateral surfaces of adjacent ones of the plurality of light emitting elements is a curved surface.

10. The method of manufacturing a light emitting device according to claim 1, wherein
the singulating of the light-transmissive substrate includes singulating the light-transmissive substrate so that
the light-transmissive member includes a first lower surface in contact with the light emitting element, and an upper surface opposite to the first lower surface and having a greater area than an area of the first lower surface.

11. The method of manufacturing a light emitting device according to claim 10, wherein
the singulating of the light-transmissive substrate includes singulating the light-transmissive substrate so that the light-transmissive member further includes a second lower surface projecting outwardly from the lateral surface connected to the first lower surface, the first lower surface and the second lower surface being made of the same material.

12. The method of manufacturing a light emitting device according to claim 10, wherein
an outer periphery of the first lower surface is located on an outer side of a light extraction surface of the light emitting element in a plan view.

13. The method of manufacturing a light emitting device according to claim 1, further comprising
providing the light-transmissive substrate as a one-piece, unitary member before the bonding of the plurality of light emitting elements onto the light-transmissive substrate.

14. The method of manufacturing a light emitting device according to claim 1, wherein
the disposing of the at least one light guiding member includes disposing the at least one light guiding member to be in contact with the outer peripheral lateral surfaces of adjacent ones of the plurality of light emitting elements.

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